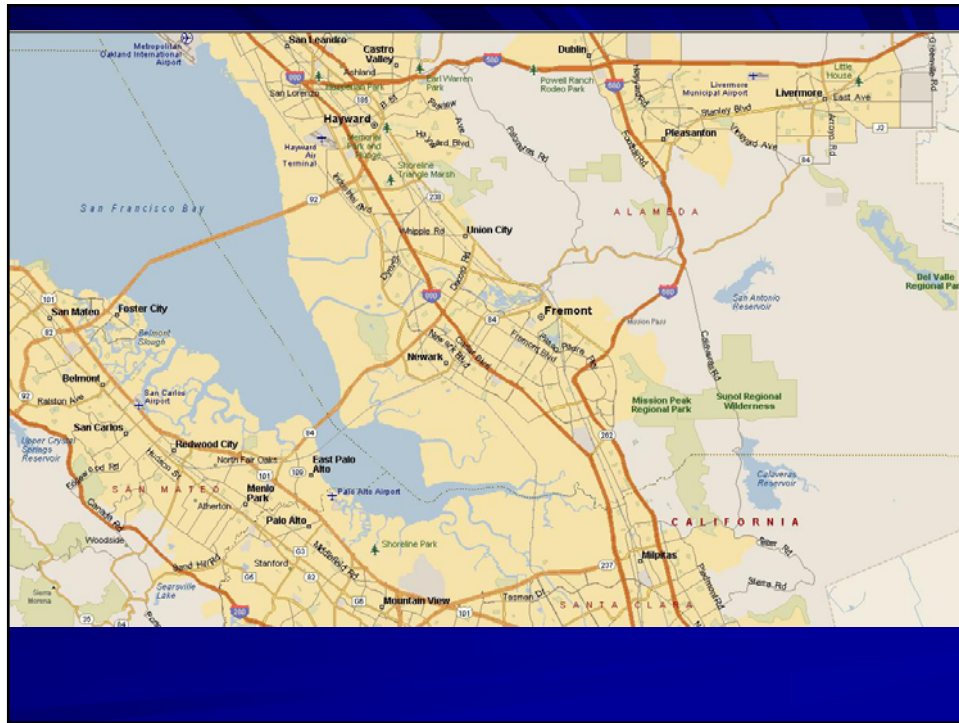


# The Construction and Failure of Calaveras Dam

## Purpose of Presentation

- Understand the Construction of Hydraulic Fill Dams
- Give Factual Information about the Failure of Calaveras Dam
- Postulate Modes of Failure



## General

- Owner: Spring Valley Water Company (Current Owner City of San Francisco)
- 210 feet-high Semi-Hydraulic Fill Dam
- 2 ½ :1 Downstream; 3:1 Upstream Slope
- Reservoir Capacity: 100,000 Acre-Feet
- Construction 1913 to 1918 and 1918 to 1925



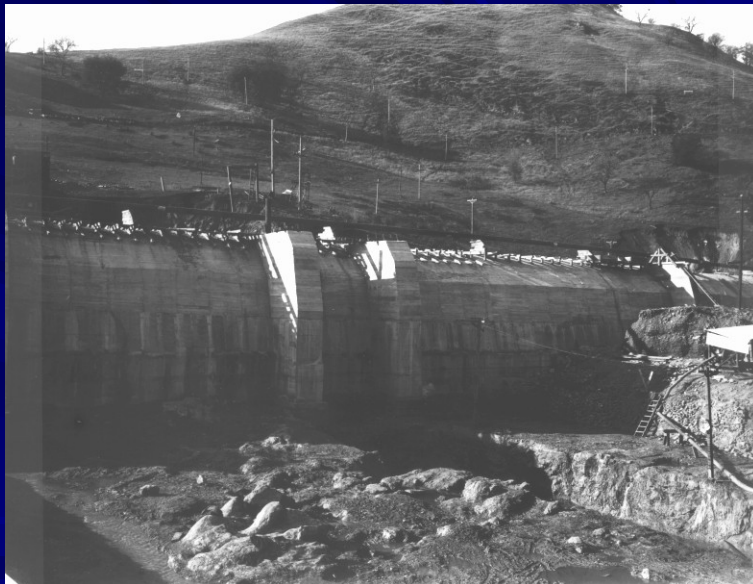
East (right) abutment.  
Foundation.



Foundation for Culvert.  
Note rock in foreground.



East (right) abutment.  
Core trench



Foundation rocks.





Core trench (25' x 10') in rock foundation  
on centerline.



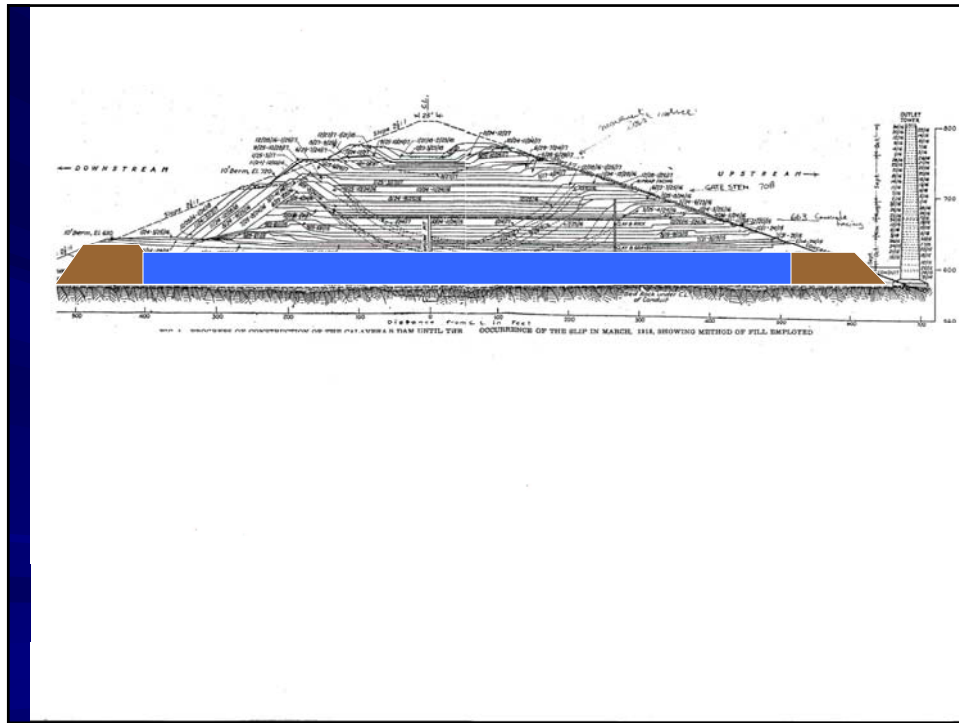
Sluicing pit.



Sluicing pit.

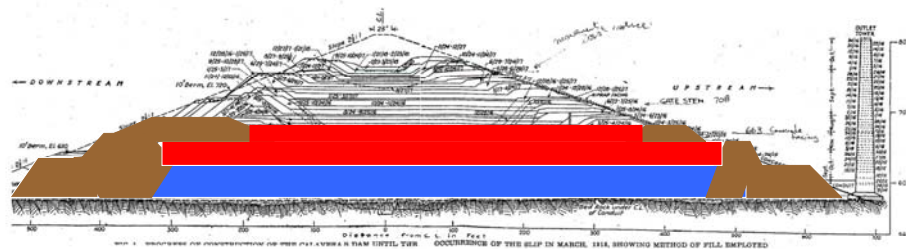


East (right) abutment. Beginning of construction: Dry rockfill and sluicing.

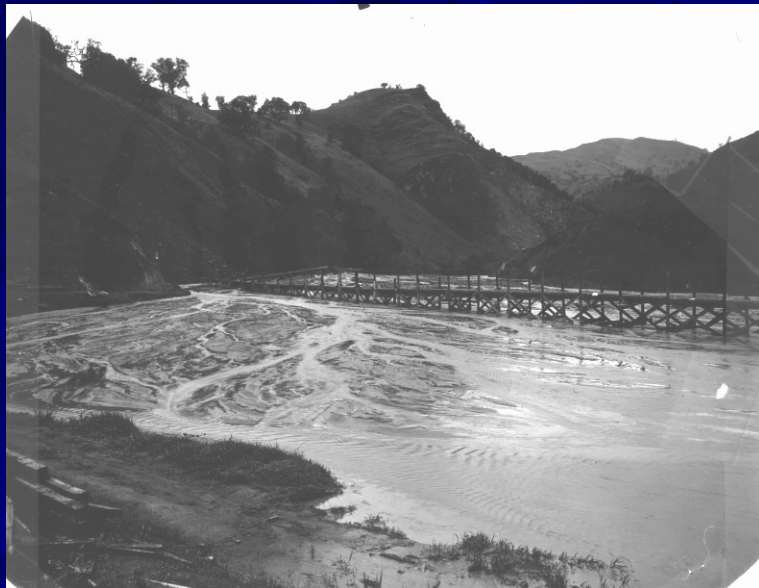




Beginning of sluicing.







Looking downstream, towards west abutment.  
Sluicing operation continuing.



Details of sluicing at cutoff trench,  
at centerline of dam

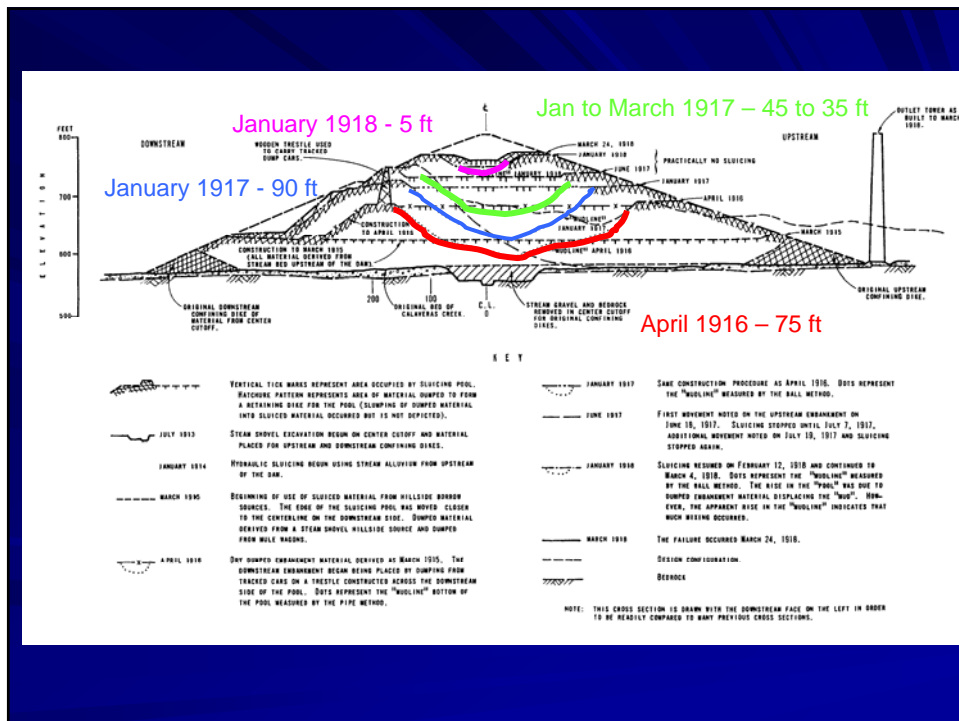


East (right) abutment.  
Sluicing continues in foreground.

# Measuring the Consolidation of Central Hydraulic Fill

How far a man could force a 1 ½ inch pipe down into material  
(1916 to 1917 75 to 90 feet)

February 12, 1917: More certain procedure was used by lowering a 6 inch cast-iron ball into the core and measuring depth



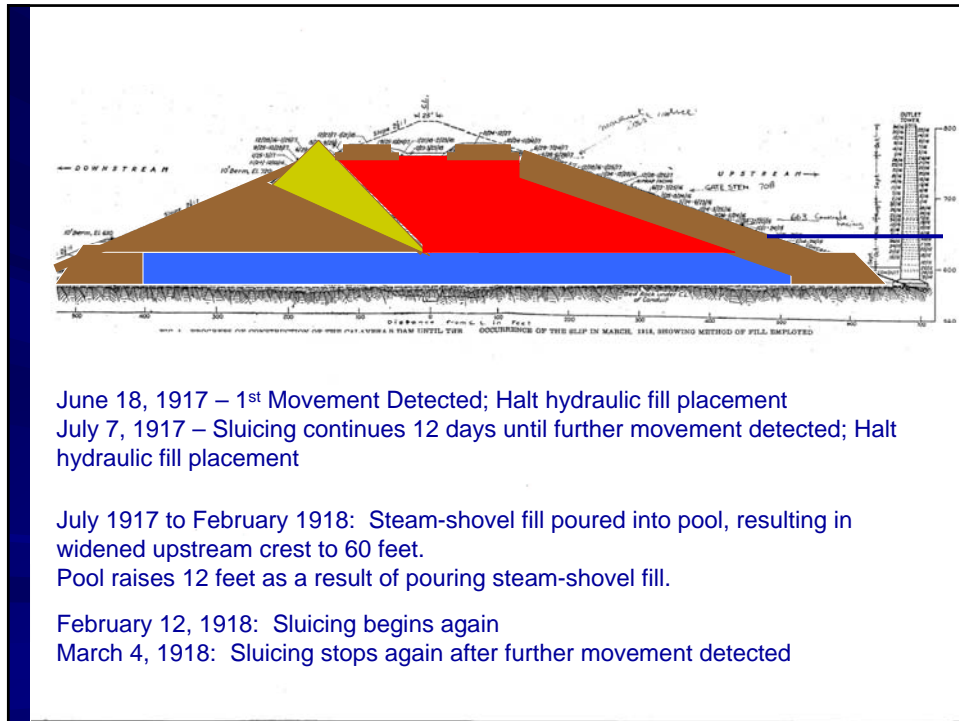


Excavation of 8-foot cutoff trench in  
east (right) abutment.



View of upstream face as  
construction continues.







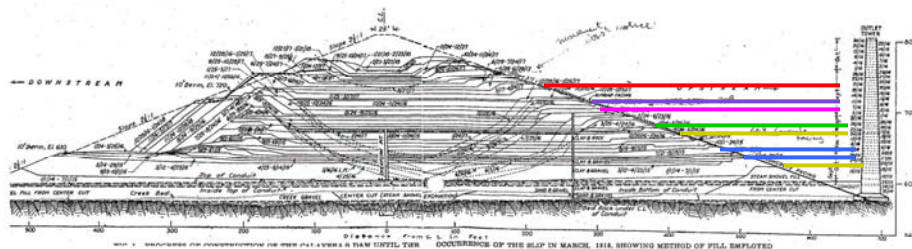
Steam shovel fill used during construction on top of hydraulic sluicing.



Excavation into rockfill on upstream berm.



Two days before slide, March 22, 1918



**Survey line 1: Elev. 729 to 731 – 1 ft. vertical movement**

**Gate Stem: Elev. 708**

**Survey line 2: Elev. 700 to 708 – 0.7 ft Horiz. 6/18 -6/21/17; 1.64 ft Horiz. to 3/4/18; 2.39 ft Horiz. To 3/23/18. Total Horizontal approx. 4 ft. 0.56 ft vertical movement**

**Survey line 3: Elev. 672 to 678 – 0.44 ft vertical movement**

**Survey line 4: Elev. 641 – 0.25 ft vertical movement**

**Top of concrete facing Elev. 663**

**Concrete Base Elev. 630**

**Reservoir W. S.: 2/12/18 - Elev. 641; 3/23/18 - Elev. 652**

# Failure of Calaveras Dam

March 24, 1917, 6:50 a.m.

Thomas J. Bliss, Pump Operator:

“I walked across the upstream face at elevation 680 feet. After getting across the dam, I noticed the upper edge of the slope concrete at elevation 663 feet raised 2 feet. Raised more at east than west end”





## Failure of Calaveras Dam

March 24, 1917, 7:10 a.m.

P. P. Tuckett, Steam Shovel Engineer:

Standing on the Downstream Crest,

“The upstream side of the downstream embankment sunk about 3 feet in the middle of the dam. I saw no evidence of movement on the upstream embankment.

I thought the pool was breathing”

## Failure of Calaveras Dam

March 24, 1917, 7:05 a.m.

Thomas J. Bliss, Pump Operator:

“After milking cow, arrived at house at 7:30 a.m.

Noticed a point about 100 ft on slope above trail, El. 710, a settlement at easterly end of 4 ft or so for a space of 60 feet axially with dam. The upstream face was moving slowly, swinging on the westerly end, moving forward more rapidly on easterly end.”



General view from top of Observation Hill.

## Failure of Calaveras Dam March 24, 1918; about 7:30 a.m.

Alice Espy, 9-year-old Daughter of  
Construction Engineer:

“The tower swayed back and forth,  
then fell straight away from the dam”

## Failure of Calaveras Dam

March 24, 1917, 7:35 a.m.

H. G. Barnes, Pipe Fitter:

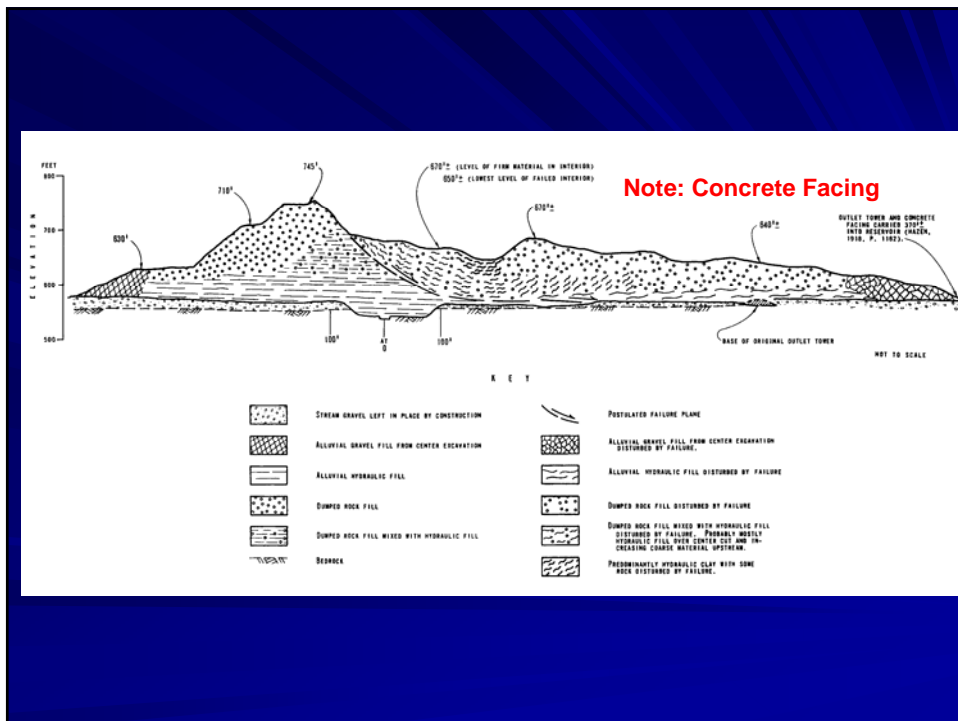
"I saw the tower tip over, the whole thing fell in one piece and did not wobble. Could see a part of the dam sliding into the reservoir with a great upheaval of water and big wave".

## Failure of Calaveras Dam

March 24, 1917, 7:35 a.m.

T. W. Espy, Resident Engineer:

Summoned by Daughter, "The easterly end of the upstream slope appeared to rise and lift a barge. The whole upstream toe moving with normal upper part settling. Looked as if east end was rotating out. The mud followed pouring out".







View of slipped material.



Day after slide, March 24, 1918.



Looking west along centerline of dam.  
Remaining downstream fill is at right.



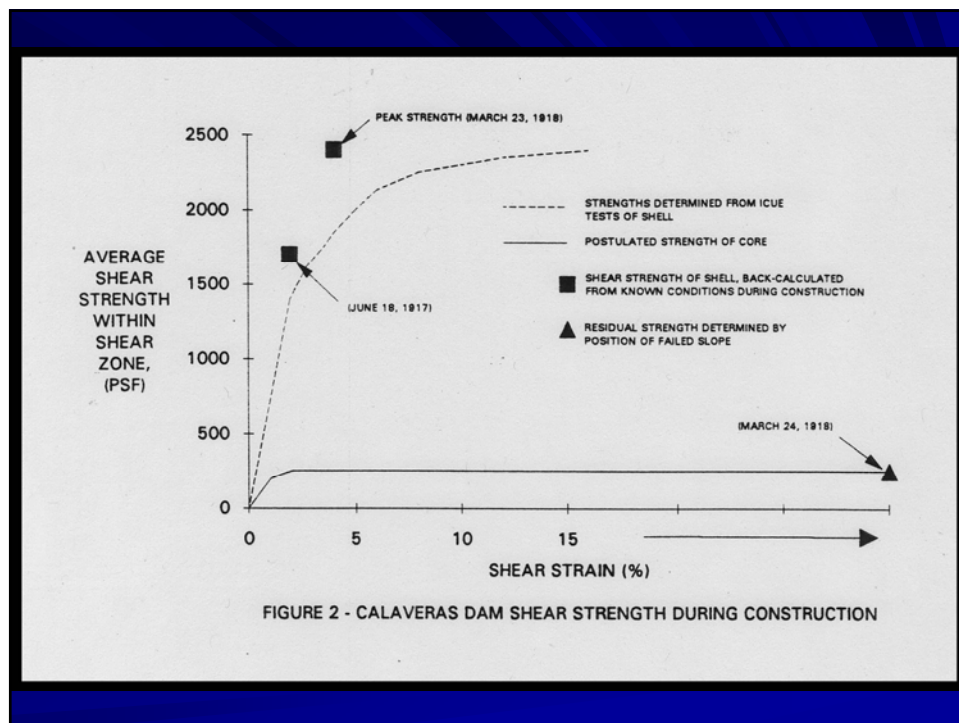
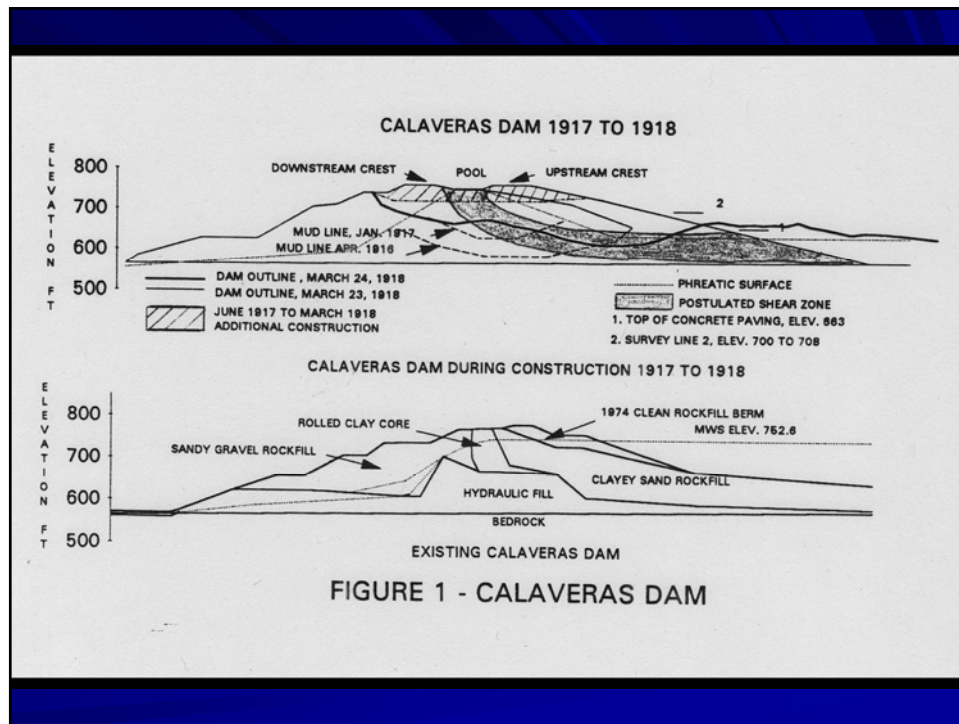
Two days after slide, March 25, 1918.

## Mode of Failure

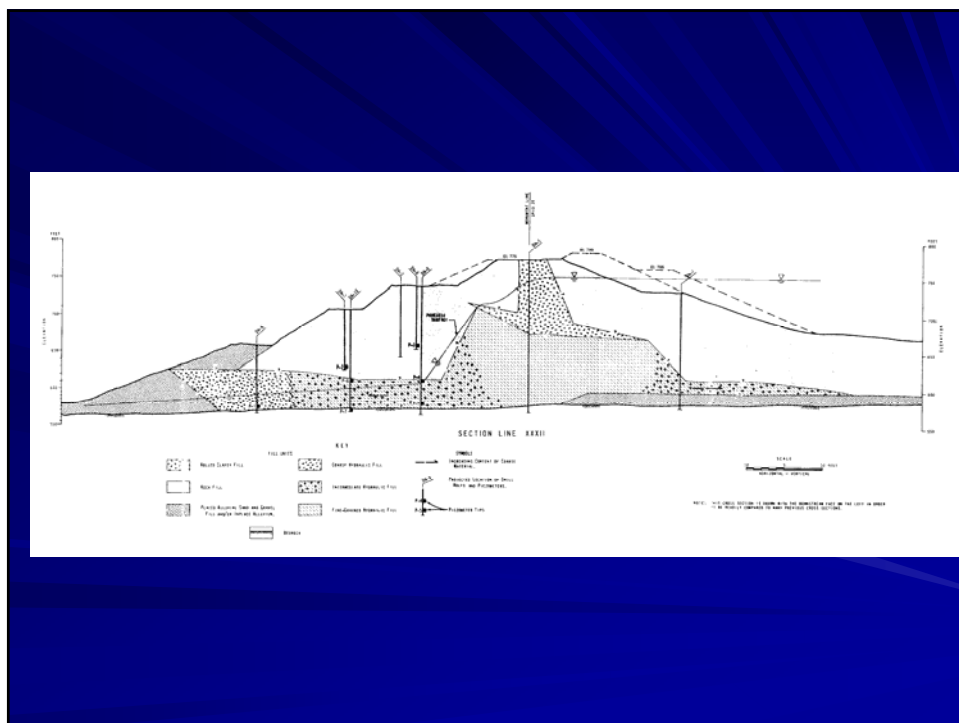
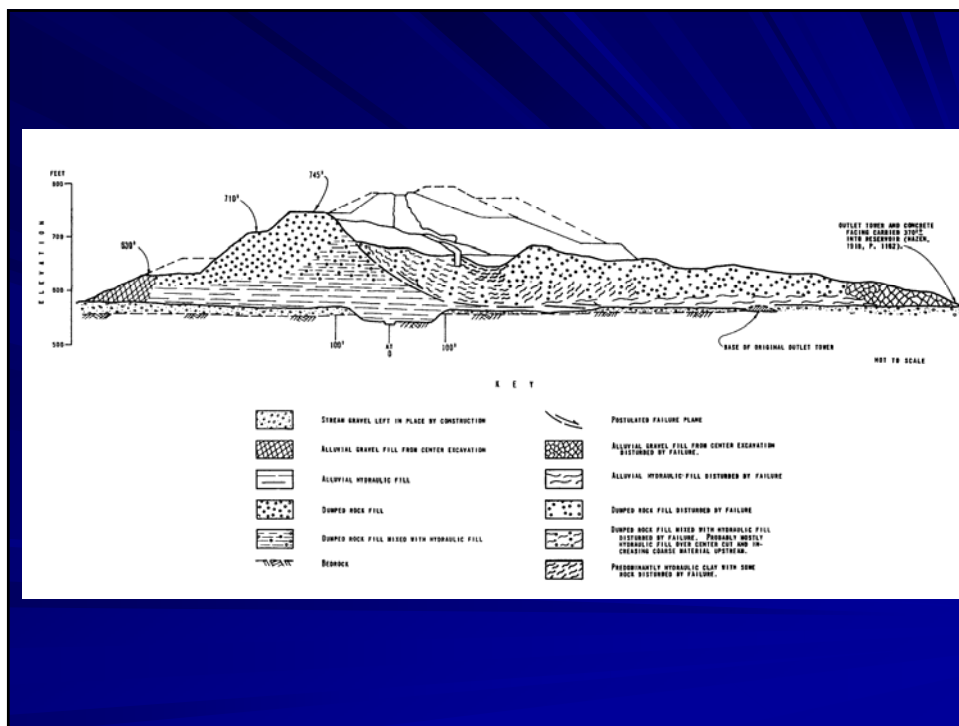
- Slip on a very thin layer?
- Zone of thickness?
- Contributing Soils/Factors
- Original Investigators conclude: Too much very fine material sluiced. Core incapable of drainage

## Mode of Failure

- Base of Concrete found 370 feet upstream
- The concrete slope 4 inches or more in thickness, lifted and cracked parallel to the upper edge and 6 feet below it for more than 600 feet.
- 45 Degree cracks with crest line, converging toward the reservoir.
- Eye witness accounts.









Calaveras Dam  
December 8, 1925

Questions